



SHAPE COEXISTENCE AND N=50 GAP: COULEX ON GROUND AND ISOMERIC STATES IN N=49 ^{79}Zn , ^{81}Ge

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55th Meeting of the INTC, CERN



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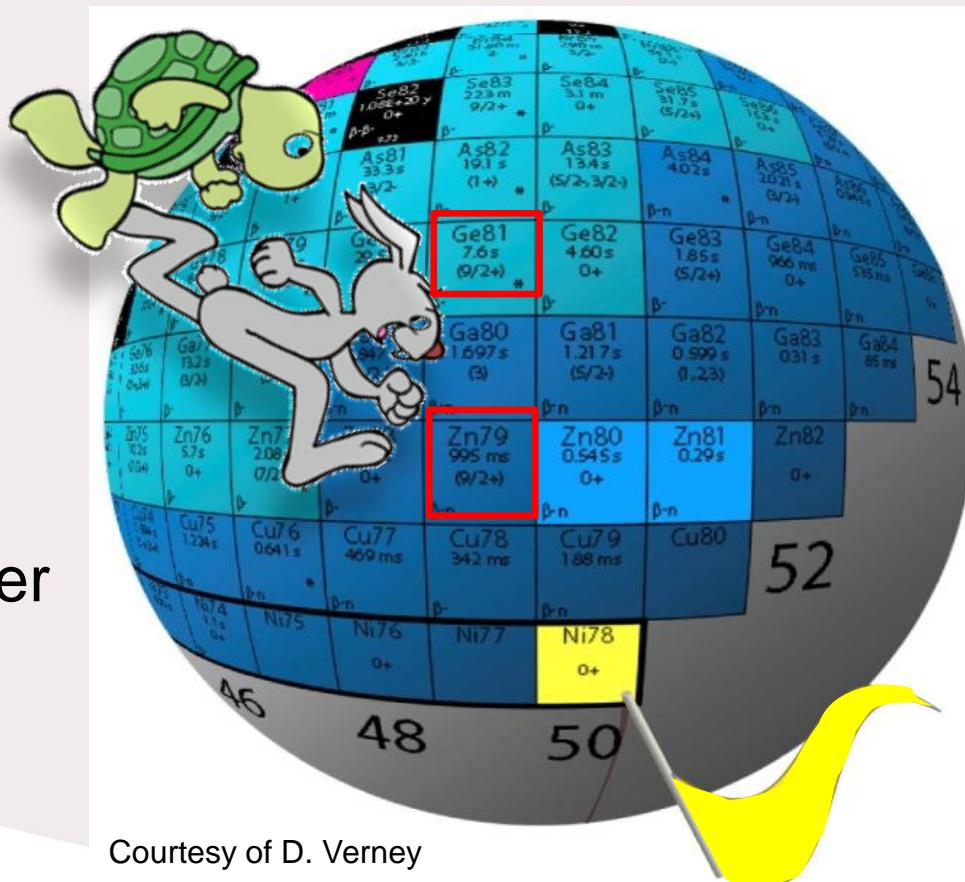
- The N=50 region
- Intruder states: a probe of collectivity-spherical gap interplay

Proposal for ^{79}Zn coulex

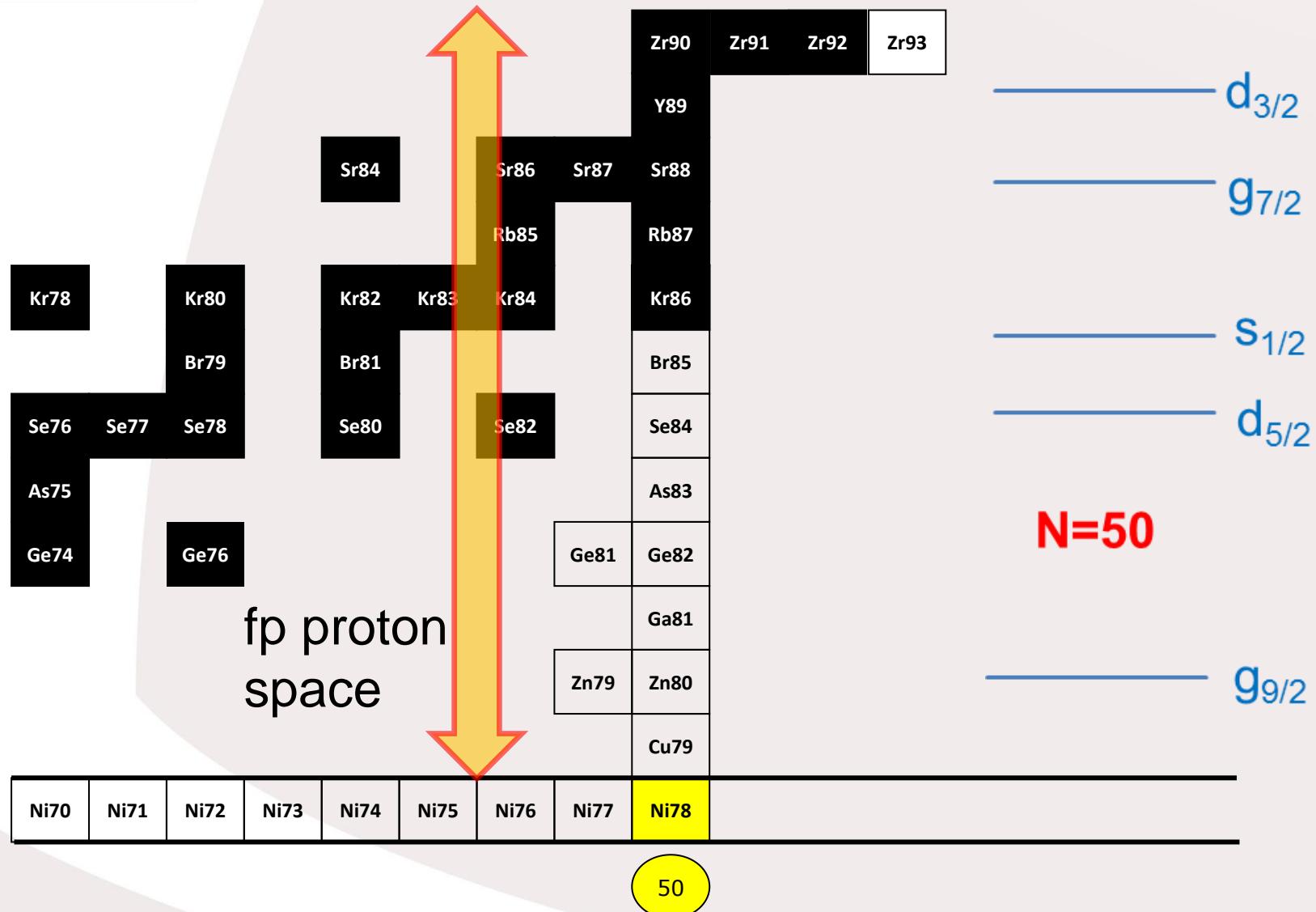
- Coulex on the isomeric $1/2^+$ state: a large spherical intruder state ?

LOI for ^{81}Ge coulex

- Same physics as for ^{79}Zn , laser ionization and yields to be measured



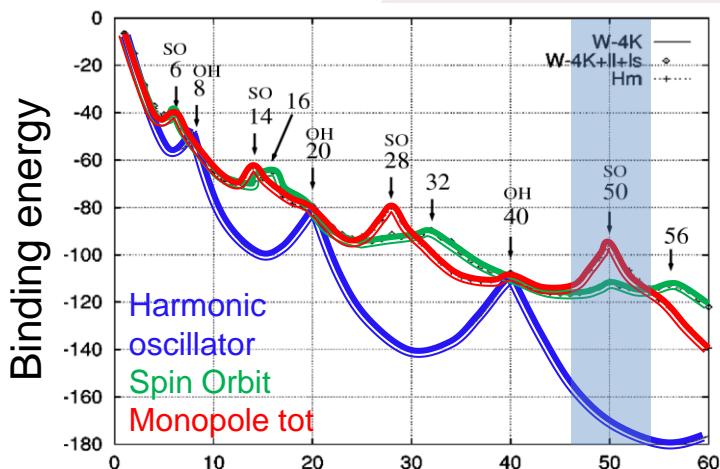
THE N=50 REGION



Quasi-SU(3) scheme: gds shells, similar case to N=20 with f_{7/2}-p_{3/2}

WHY ARE THERE SHELL CLOSURES ? THE CASE OF N=50

J. Duflo et A. P. Zuker, Phys. Rev. C 59, R2347 (1999)



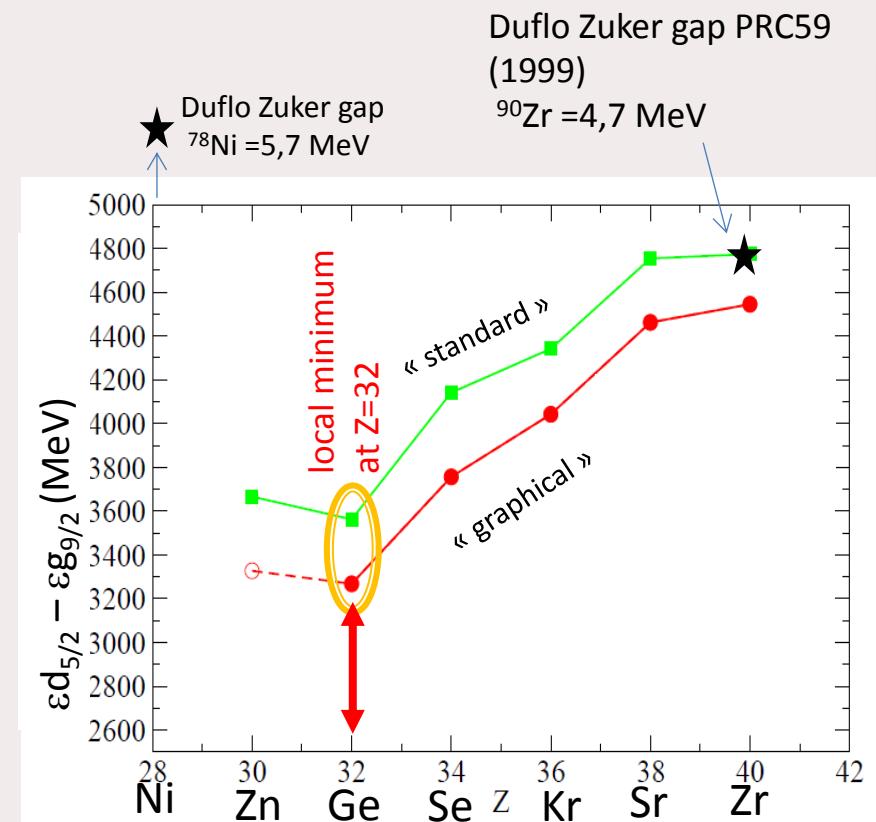
Reduction of the N=50 spherical gap from N=51 isotones mass ?

M.-G. Porquet and O. Sorlin, Phys. Rev. C 85, 014307 (2012)

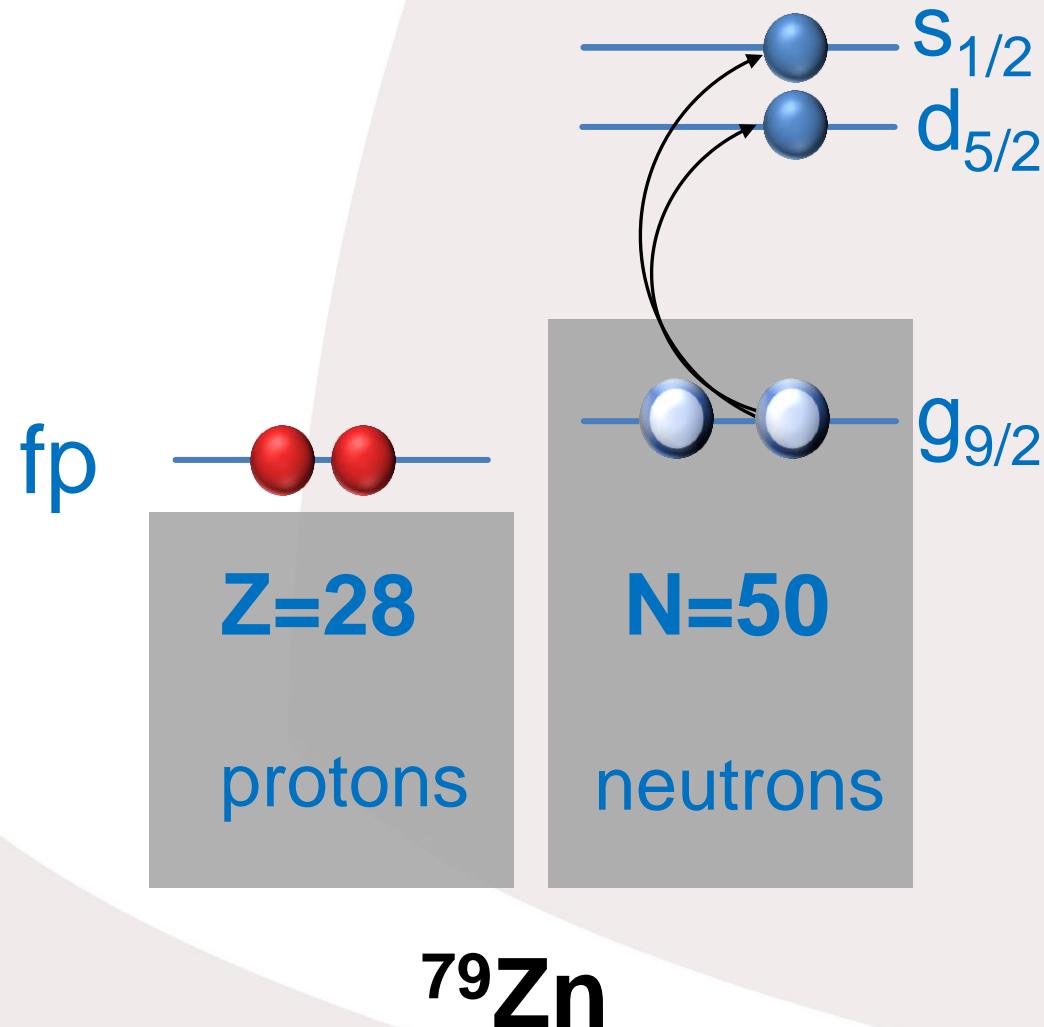
K. Sieja et F. Nowacki, Phys. Rev. C 85, 051301(R) (2012)

3-body interactions produce “naturally” the shell gap

A. P. Zuker, Phys. Rev. Lett. 90, 042502 (2003)



p-h INTRUDER STATES AS PROBES OF GAP

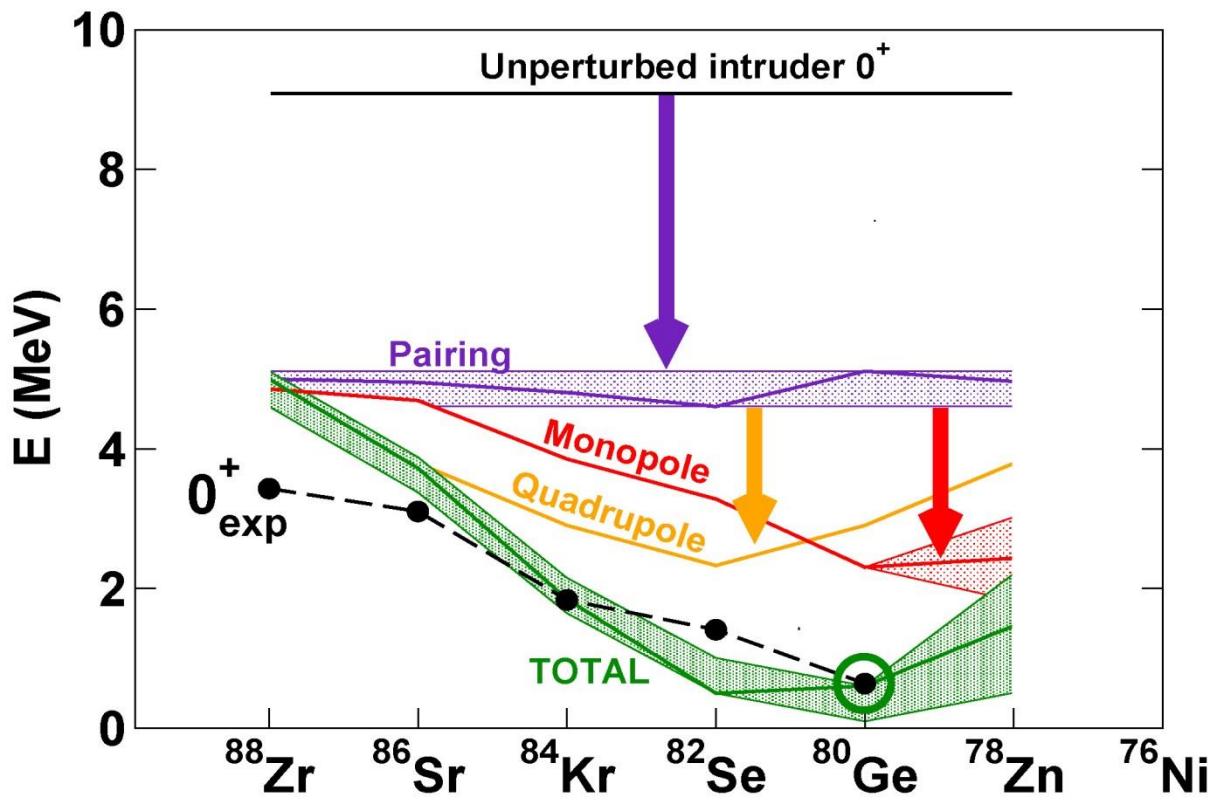


1 particle – 2 hole
across N=50

- Spherical gap (1p-2h):
energy cost 
- Correlations by breaking the core:

energy gain 

RESULTS SO FAR: INTRUDER 0^+ IN ^{80}Ge



A. Gottardo, D. Verney et al.,
Phys. Rev. Lett. 116, 182501 (2016)

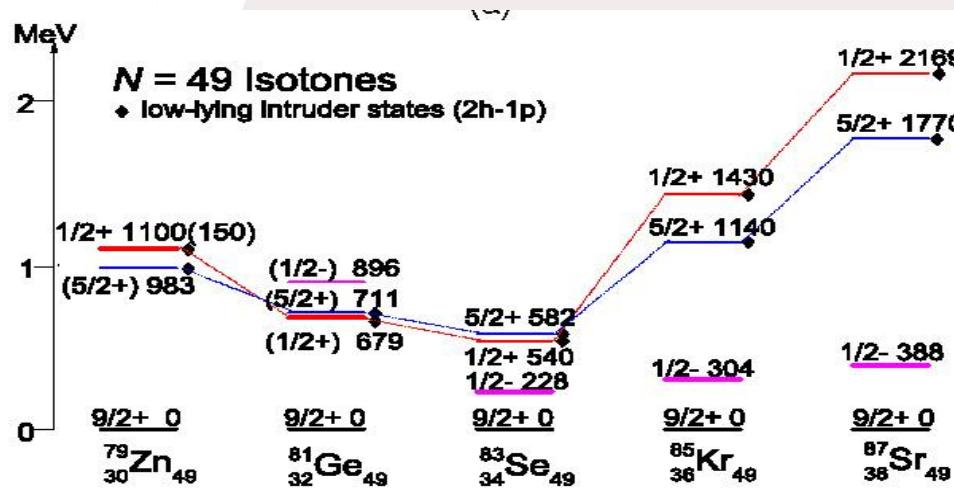
Shape coexistence in ^{78}Ni ?

- Monopole evolution towards $Z=28$: mass measurement in ^{83}Zn
- Reduction the $Z=28$ gap (increased quadrupole) ?



Possibility of finding a
(2p-2h) 0^+ state in ^{78}Ni
around 2.5 - 3 MeV

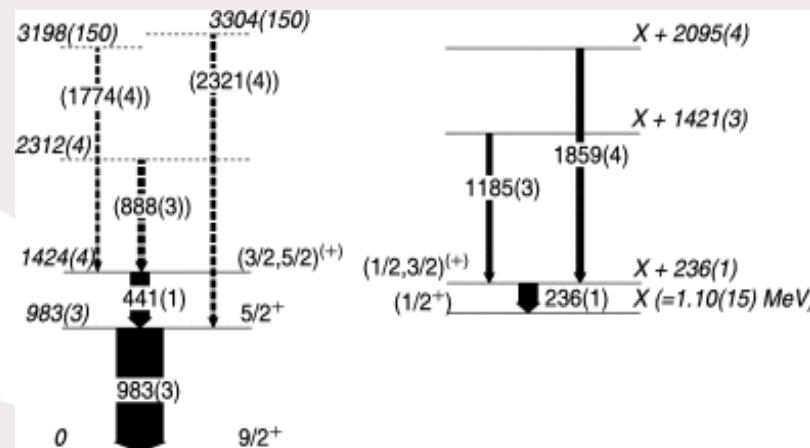
RESULTS SO FAR: INTRUDER STATES IN N=49 ISOTONES



X. F. Yang et al. Phys. Rev. Lett. 116, 182502 (2016)

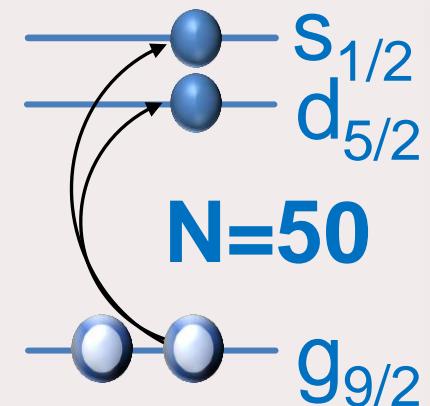
(d,p) measurement:

R. Orlandi et al., Phys. Lett. B 740, 298–302 (2015)



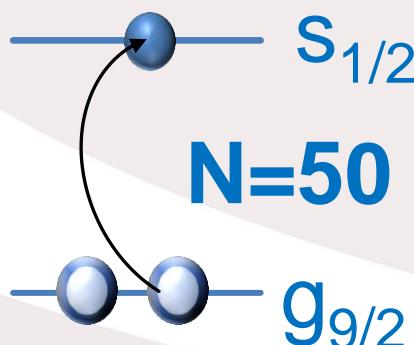
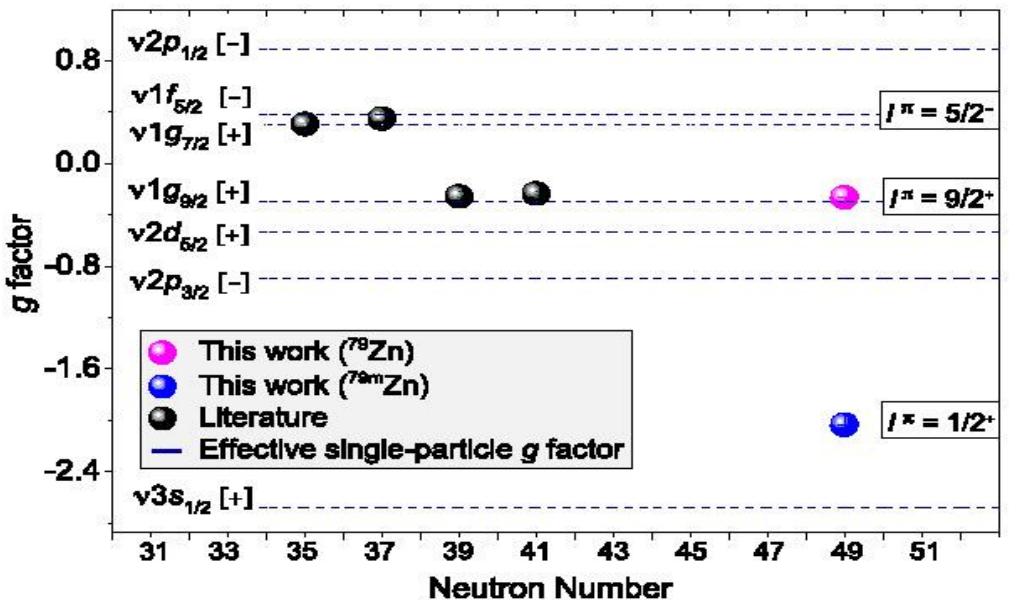
Intruder states (1p-2h) in N=49 states:

- Minimum at Z=34
- Inversion $1/2^+ - 5/2^+$
- Pure $s_{1/2}$ wave function ? Shape ?



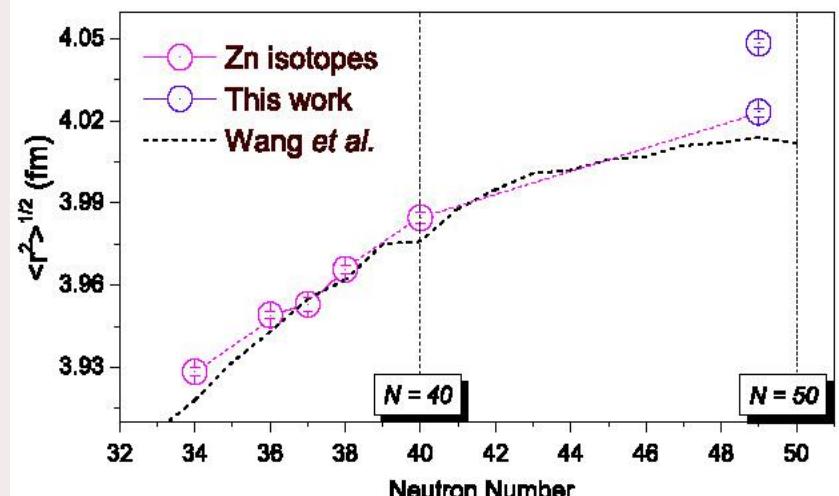
ISOMER SHIFT IN N = 49 ISOTONES

X. F. Yang et al. Phys. Rev. Lett. 116, 182502 (2016)

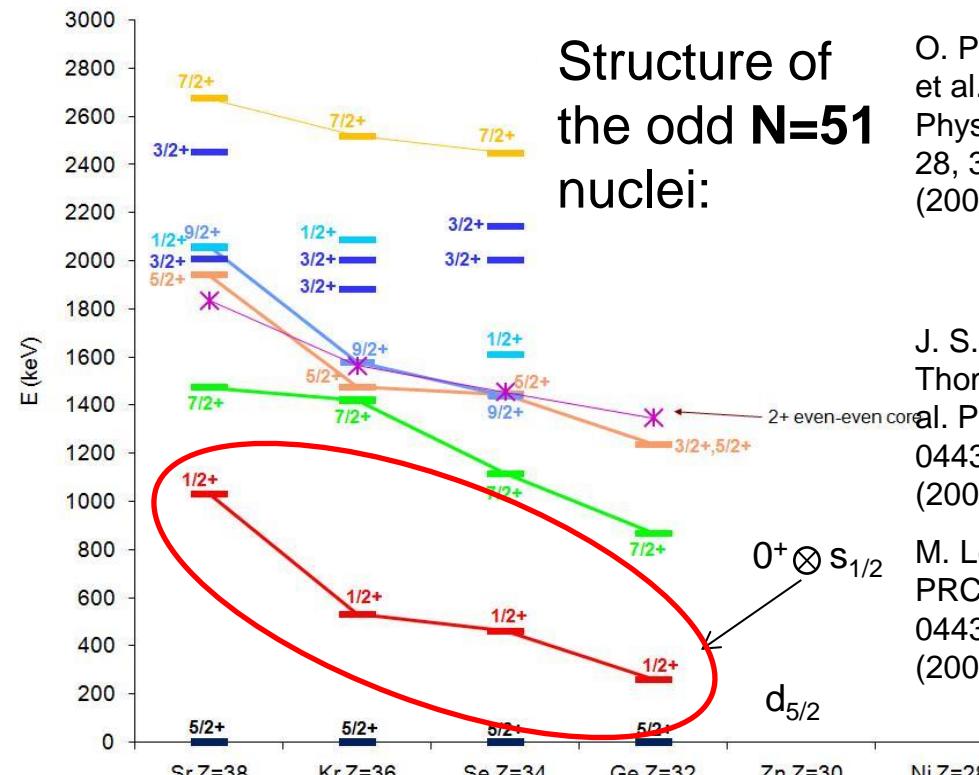


1. The $1/2^+$ state in ^{79}Zn has a dominant $\nu(g_{9/2}^{-2} s_{1/2})$ character
2. Large isomer shift. Large deformation ($\beta \sim 0.22$) or large radius ?

$$\langle r^2 \rangle \approx \langle r^2 \rangle_0 \left(1 + \frac{5}{4\pi} \langle \beta^2 \rangle \right)$$



S_{1/2} LOWERING: COUPLING TO THE CONTINUUM ?



Courtesy of D. Verney

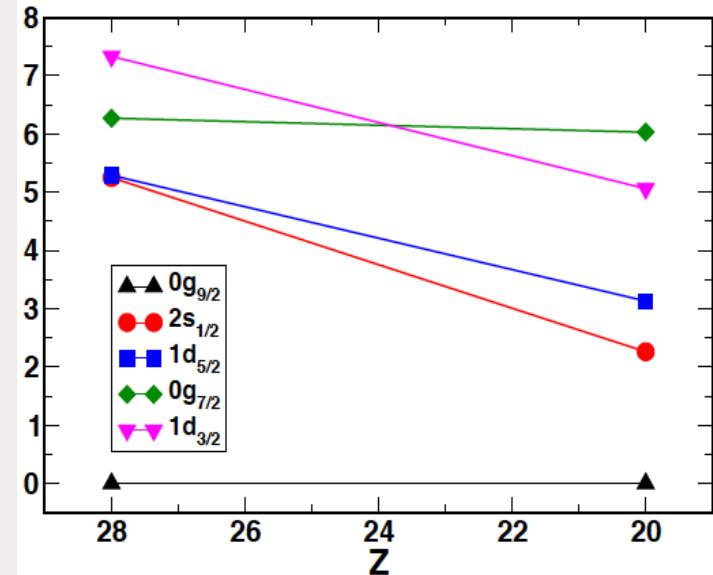
Lowering of the $s_{1/2}$ shell:
coupling to the continuum,
halo in ⁷⁹⁻⁸⁰Ni ?

O. Perru
et al. Eur.
Phys. J. A
28, 307
(2006)

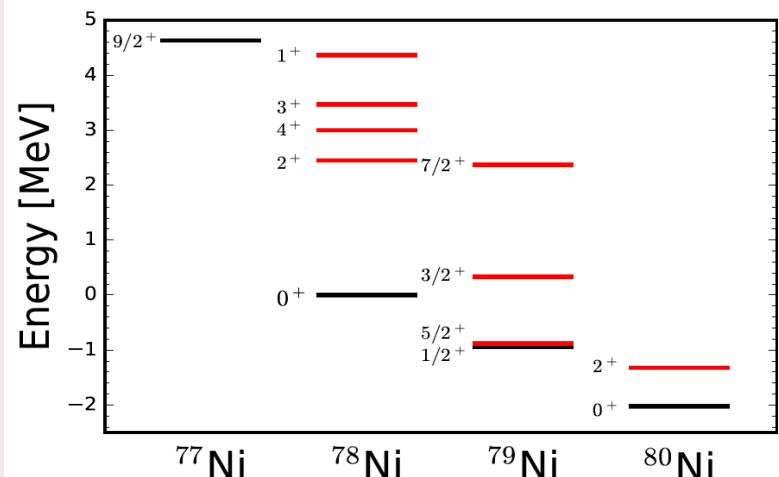
J. S.
Thomas et
al. PRC **76**,
044302
(2007)

M. Lebois
PRC **80**,
044308
(2009)

F. Nowacki et al., Phys. Rev. Lett. 117, 272501 (2016)



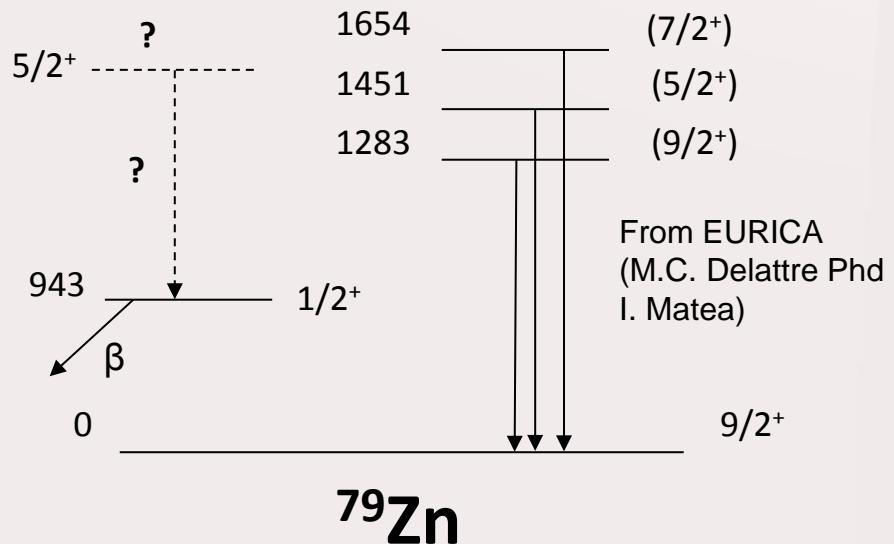
G. Hagen et al., Phys. Rev. Lett. 117, 172501 (2016)



COULEX OF: ^{79}Zn g.s. AND ^{79}Zn isomer

- $9/2^+$ (1h): B(E2) of ^{80}Zn (1.6 Wu \downarrow);

γ ray \sim 1200-1600 keV,
 $\gamma\gamma$ coincidences



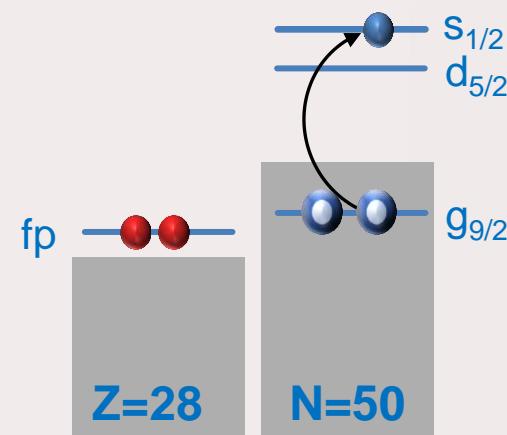
We will get:

- 1) $2^+(^{78}\text{Zn}) \otimes s_{1/2}$ ($5/2^+, 3/2^+, 1/2^+$) energy

If $\beta \sim 0.22$: Nilsson orbitals, γ rays \sim 400-1000 keV (2^+ of ^{78}Zn 730 keV)

- 2) B(E2): If $\beta \sim 0.22$ then

B(E2: $5/2^+ \rightarrow 1/2^+$) \gtrsim B(E2) of ^{78}Zn (1.6 Wu \downarrow)



Different energies/B(E2):
other phenomena (small β , large radius)

SETUP

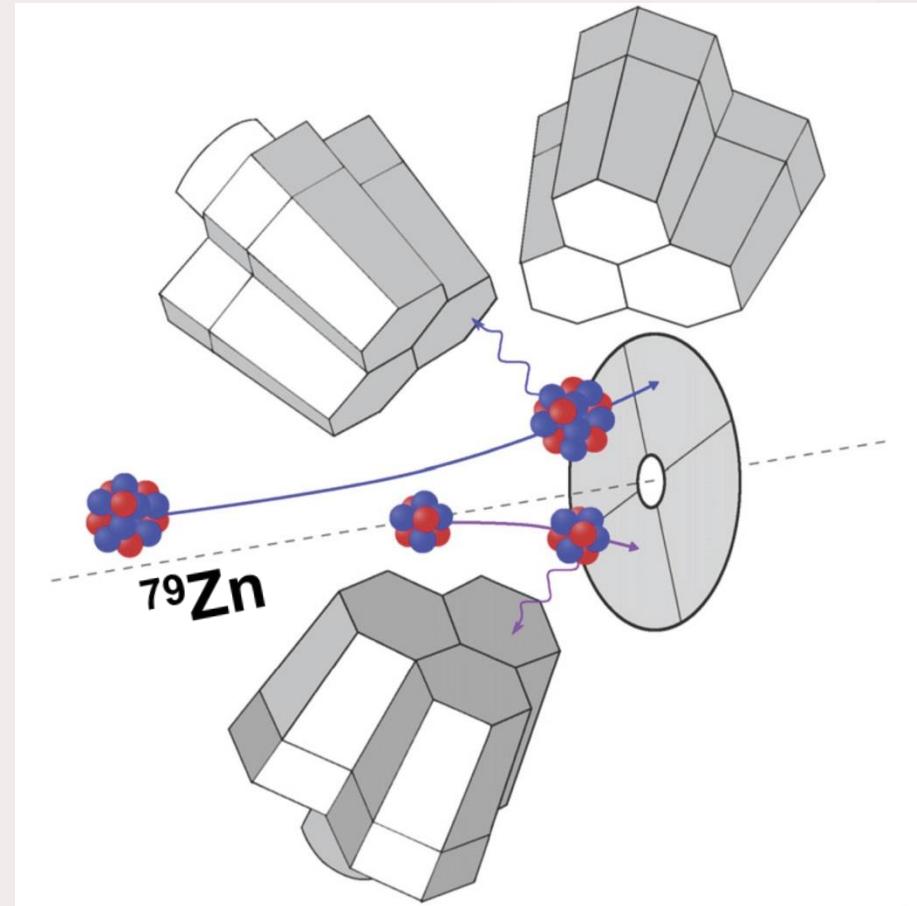
Scattering angles:

16-60 degrees in the LAB frame
(scattered beam and target recoils detected)

GOSIA calculation:

- 4 mg/cm² Pt target
- Excitation of 5/2⁺, 3/2⁺ multiplet
700 keV above the isomer
- 2 W.u. B(E2↓)

3.4 MeV/u beam will maximize
particle- γ coincidences
(GOSIA simulations done up to 5
MeV/u)



BEAM TIME REQUEST / LOI FOR ^{81}Ge

	Yield ^{79}Zn	Yield $^{79}\text{Zn}^*$	Coulex $1/2^+$ Particle- γ coinc	Shift requested
GOSIA calculations	$\sim 5 \cdot 10^3$	6 %	15/shift	21 (7 days)

- Considering laser OFF/ON (30%), multiplet (60% feed), we estimate 150 counts for the $3/2^+$, $5/2^+$ peaks.
- (TAC) Quartz line will reduce Ga contamination, but laser off measurement required also to be sure that new lines originate from ^{79}Zn . Neutron converter if convenient

LOI: same physics case, study of $1/2^+$ isomer in ^{81}Ge (isomer shift measurement approuved):

Need for ^{81}Ge developement and on-line yield test.

COLLABORATION

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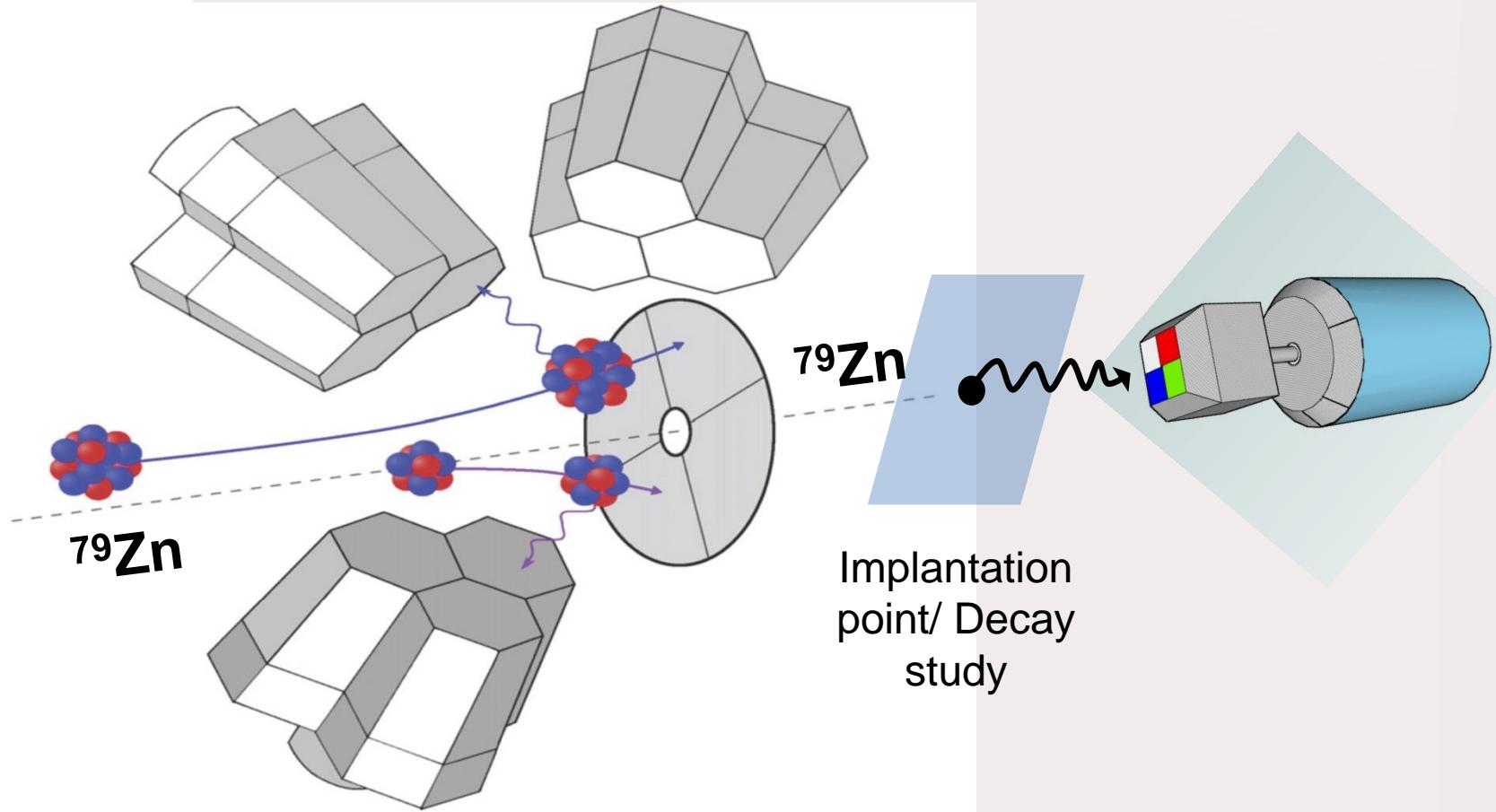
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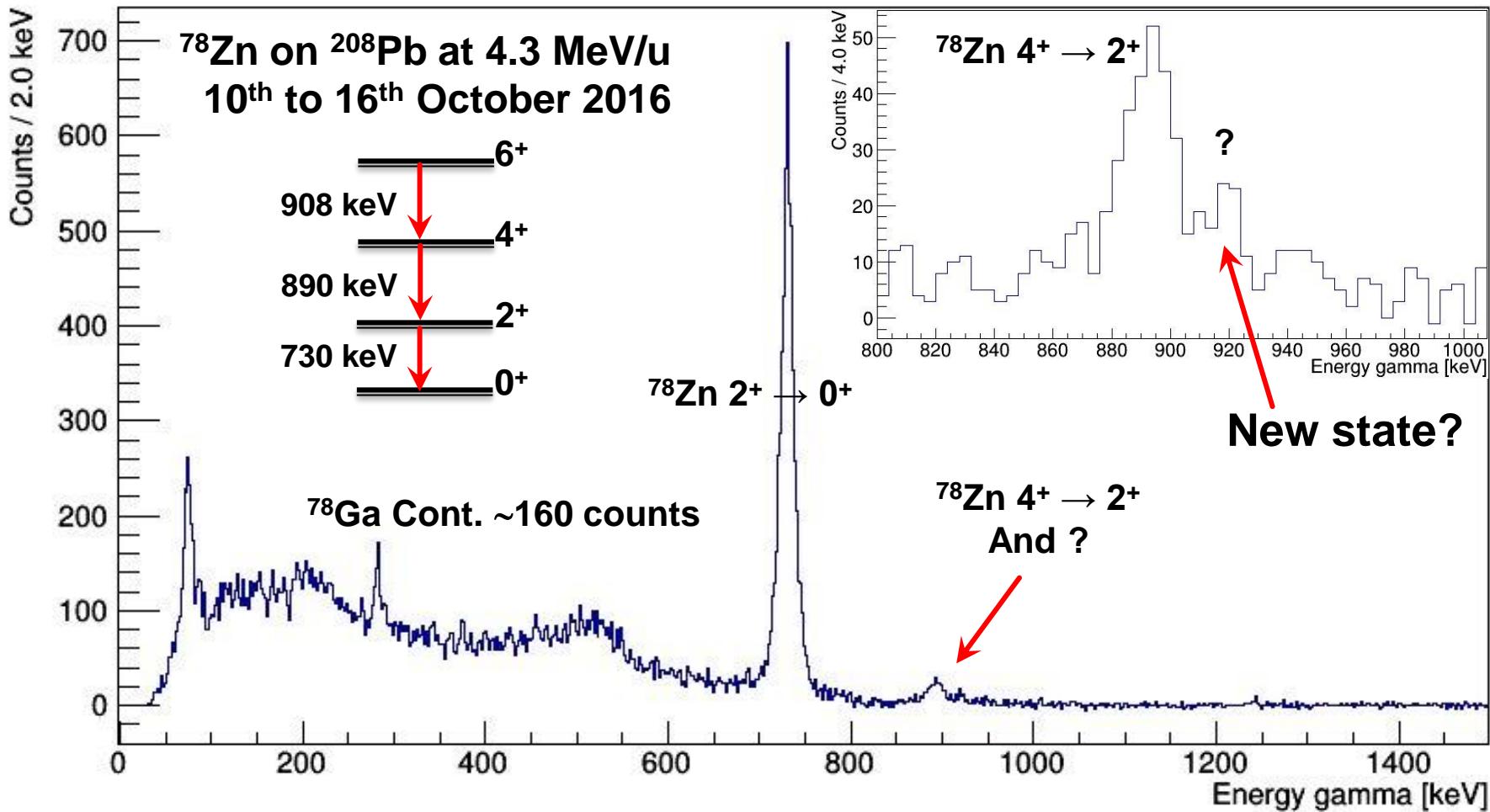
²²*Université de Strasbourg, IPHC, F-67037 Strasbourg, France and CNRS, F-67037 Strasbourg, France*

DECAY SPECTROSCOPY BEHIND MINIBALL



^{78}Zn COULEX 2016 (COURTESY OF A. ILLANA SISON)

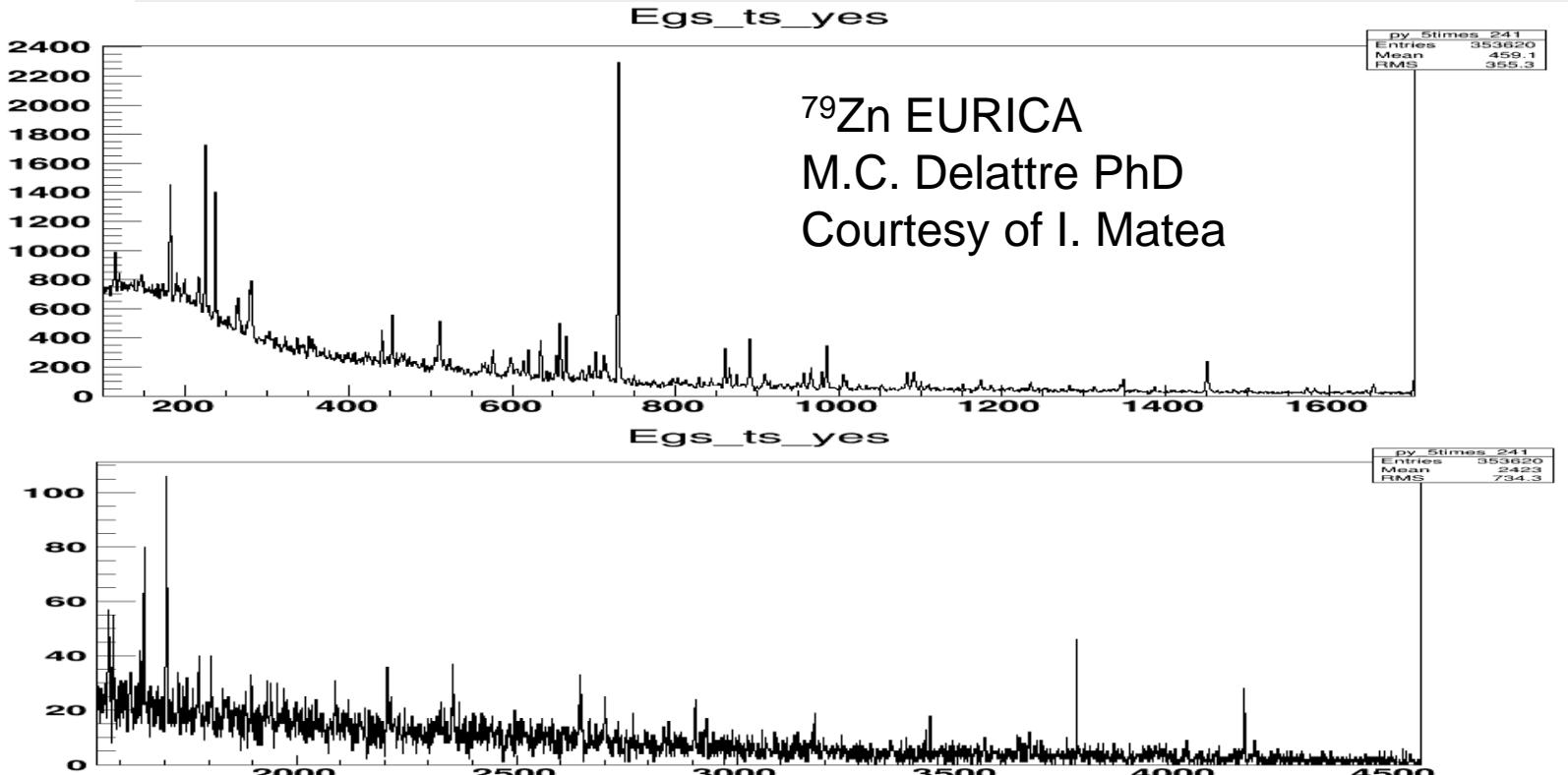
$$B(E2 \uparrow) \approx \left(\frac{3Ze\langle r^2 \rangle_0}{4\pi} \right)^2 \beta^2$$



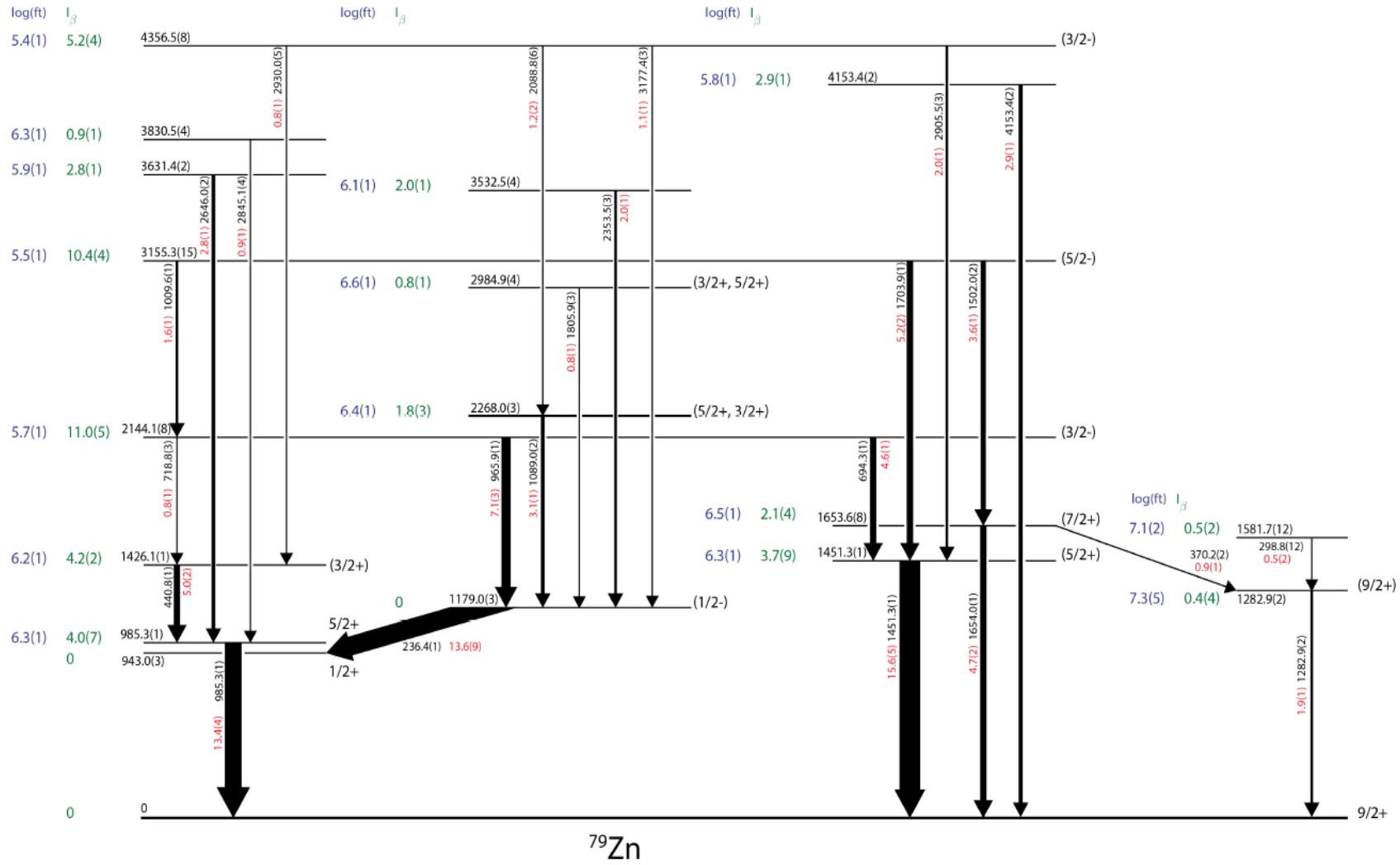
1/2⁺ ISOMERIC RATIO

EURICA experiment: $^{79}\text{Cu} \rightarrow ^{79}\text{Zn} \rightarrow ^{79}\text{Ga}$:

- by tagging on gammas we know $(^{79}\text{Zn})1/2^+$ and $(^{79}\text{Zn})9/2^+$
- Then look at ^{79}Ga gamma rays (well known) and compare intensity ratios with our case
- Online monitoring of $(^{79}\text{Zn})1/2^+$ 6% isomeric ratio at the MINIBALL «beam dump»



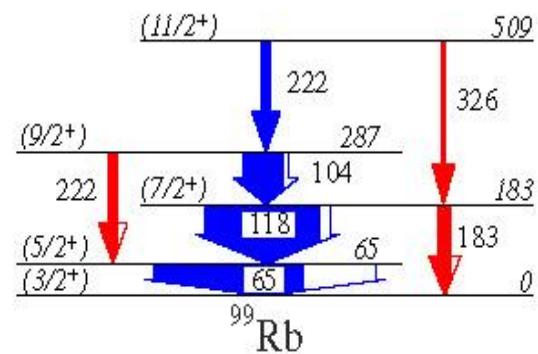
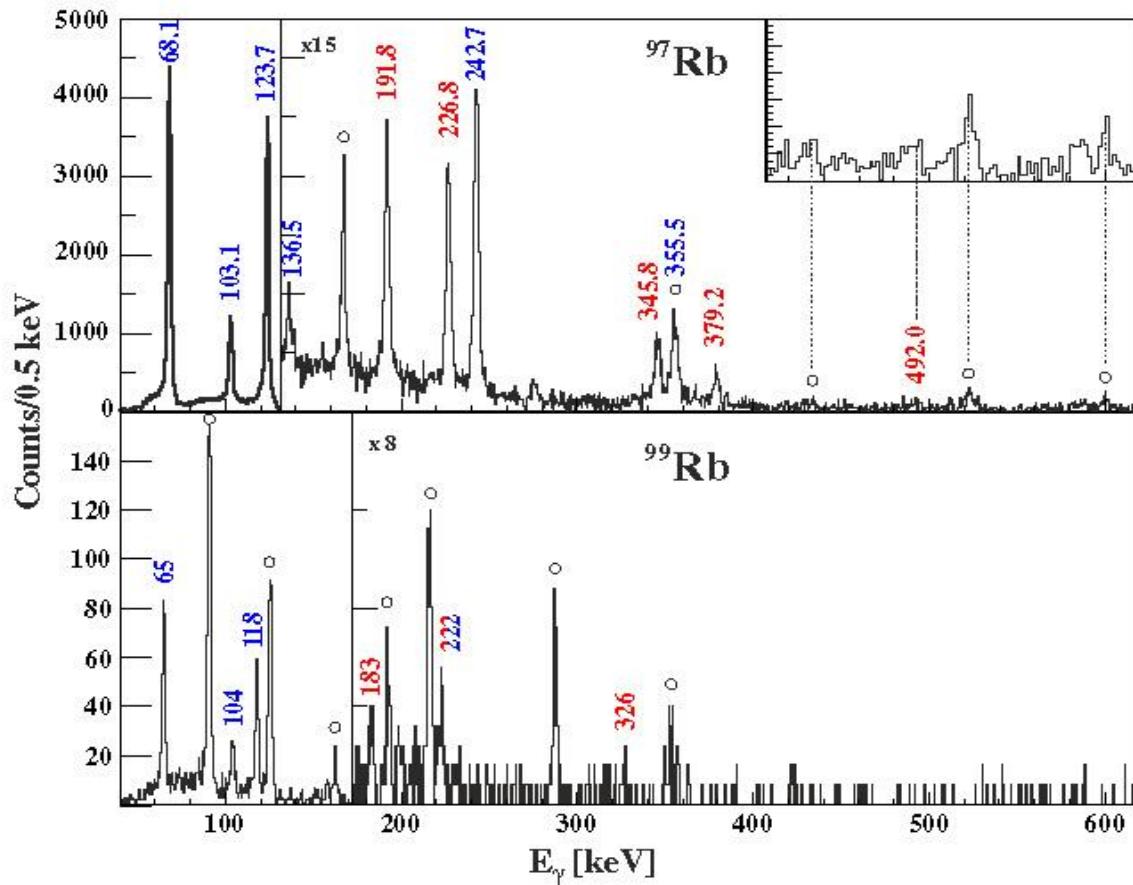
⁷⁹Zn EURICA RIKEN



EXAMPLE: ^{99}Rb COULEX

C. Sotty *et al.*

Phys. Rev. Lett. 115, 172501 (2015)



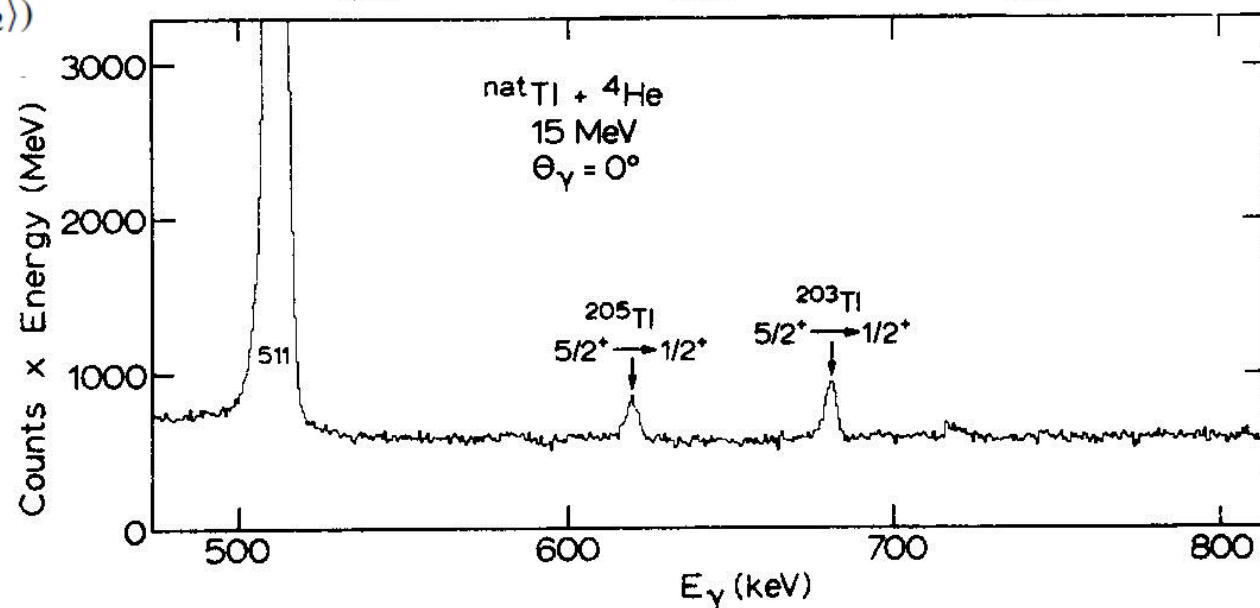
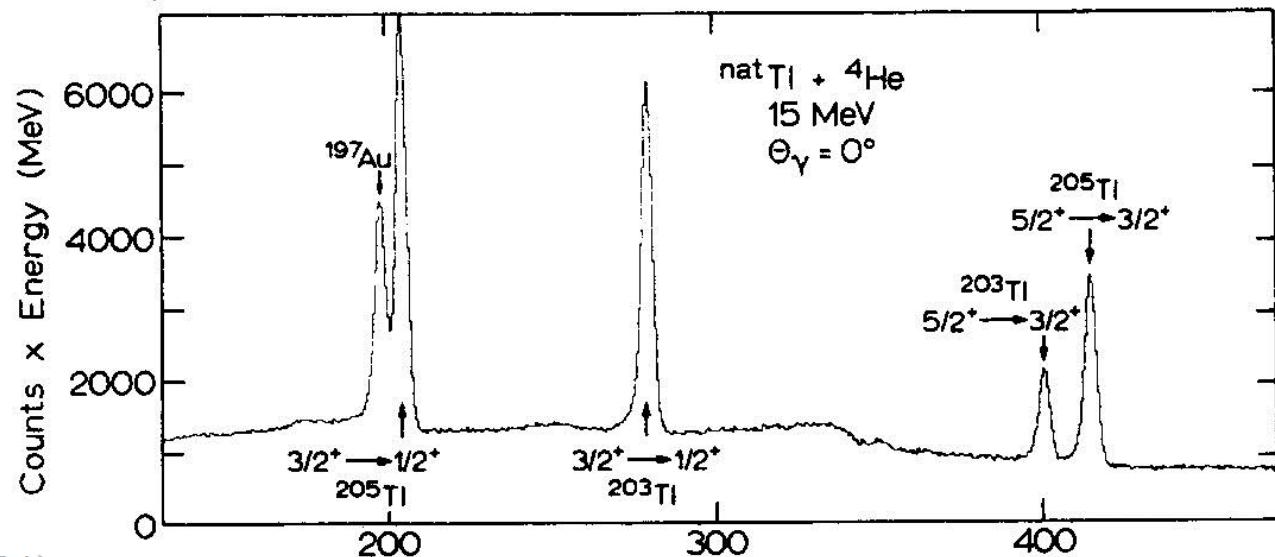
Few stat. sufficient for
 $Q_0 = 2.8(0.5) \text{ eb} !$

THE EXAMPLE OF ^{205}TI : COULEX of $1/2^+$ g.s.

^{206}Pb (803 keV):
 $B(E2 \downarrow 2^+ \rightarrow 0^+) = 200 \text{ e}^2\text{fm}^4$

^{205}TI :
 $B(E2 \downarrow 5/2^+ \rightarrow 1/2^+) = 500 \text{ e}^2\text{fm}^4$

$$Q_0 = \frac{3}{\sqrt{5\pi}} Z e R^2 \langle \beta_2 \rangle (1 + 0.36 \langle \beta_2 \rangle)$$



CROSS SECTIONS AS A FUNCTION OF ENERGY

GOSIA calculations

Cross section 1.25 b at 0.7 MeV, 10 Wu ↑

300 keV : 2.25 b

400 keV : 1.9 b

500 keV : 1.75 b

600 keV : 1.6 b

700 KeV : 1.25 b

800 keV: 1.0 b

1 MeV : 650 mb

1.2 MeV: 400 mb

1.4 MeV: 250 mb